A SAMPLE SURVEY OF THE ONEIDA LAKE SPORT FISHERY

BU-241-M

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Abstract

This paper outlines briefly the major sampling problems encountered in a survey of the Oneida Lake sport fishery. Primary emphasis is on sources of bias in estimates of total fishing effort, catch rate and total catch. The most troublesome biases arose in estimation of mean catch rate. Potential for bias in mean catch rates on fishery surveys in general is discussed.

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INTRODUCTION

In recent years the demand for outdoor recreational facilities in the U.S. has been increasing very rapidly, in conjunction with increased prosperity and more leisure time. This growth has generated a need for more quantitative information on outdoor recreational resources and their use, to aid in planning for the future.

Sport fishing has long been a major form of outdoor recreation and as early as the 1920's, special surveys called creel censuses were conducted to determine angler success for evaluating fishery management practices. Subsequent spectacular growth of sport fishing has led to many more surveys with expanded objectives which have included estimation of total sport fishing activity and economic values, as well as some index of fisherman satisfaction.

Collecting information on a sport fishery poses general types of sampling problems which are similar to those found in any other social or economic survey, and consequently the basic principles of sample survey methods and theory are applicable. For example the general objective of obtaining the desired information with required accuracy at minimum cost, is common to virtually all surveys. There are, however, a number of unique aspects of sport fishing which can have important implications in the choice of appropriate statistical procedures.

The objective of this paper is to outline briefly the major sampling problems encountered in a survey of the Oneida Lake sport fishery (Grosslein, 1961)[1]. Primary emphasis will be on sources of bias. Most of these problems are common to sport fishery surveys in general and some of them are similar to the problems which will be encountered in other types of outdoor recreation surveys.

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[1] This paper contains material presented (verbally) at the N. E. American Fishery Society Meeting, Monticello, New York, May, 1962. It is an outline of portions of my thesis (Cornell University), which are now in preparation for publication.

OBJECTIVES OF THE SURVEY

An important first step in any survey is the preparation of a clear statement of objectives. To be of maximum value this statement must be a detailed listing of all the quantities for which estimates are sought, preferably with some idea of the desired precision of each estimate and its rank on a priority scale.

In the Oneida Lake Survey, the primary objectives were to estimate the total angler harvest of walleyes (stizostedion v. vitreum) within ± 20% of the true value, and to evaluate the sample survey chiefly from the standpoint of factors affecting bias and precision of total catch estimates. Information was also desired on other characteristics of the Oneida Lake sport fishery such as species composition of the catch and angler preferences, but these items had lower priorities. No information was sought on money spent by fishermen or the distance they traveled, frequency of fishing trips, etc.

FISHING EFFORT

Angler Counts and Sample Design.

The methods and estimators used in estimation of fishing effort depend chiefly upon the size of the body of water and access to it. Whenever access is extensive, it is necessary to count anglers on a sampling basis. Unbiased estimation of numbers of anglers (or more precisely angler-hours) requires among other things that randomization of counting schedules within a given day, say, be applied to discrete (and non-overlapping) time intervals whose duration is the amount of time required to complete a count.

For example, in the Oneida Lake study it was possible to obtain an index of the number of anglers, by counting boats with a telescope from a single vantage point. A single count required 30 minutes and in this case unbiasedness would require that half-hour counting periods be randomly selected from the total number of half-hour periods in the day (or time stratum within the day). When counting requires more than a small segment of a day and must be done by traversing the fishery (e.g., by boat or plane on a river), then randomization of starting places and travel directions is desirable as well as randomization of counting periods within the day. The purpose of randomization is of course to obtain a valid estimate of sampling error as well as to avoid potential bias arising from the distribution of anglers through space and time, which is nearly always characterized by systematic patterns. The composition of angler populations (e.g., residents vs. non-residents) can be expected to exhibit systematic patterns also, and the above remarks about sample design are applicable.

The problem of precision in estimating total effort is straightforward. That is, precision is a function of variability in the amount of fishing, sample design and frequency of counting (size of sample). Stratification of a season into subunits and sub-subunits (e.g., months, weeks within months, weekend days vs. weekdays winthin weeks, and even periods within days) will nearly always yield a gain in precision of estimated total effort. In the Oneida Lake study standard errors of estimated total summer fishing effort during daylight hours were less than 5 percent of the total.

<u>Units of Effort.</u>

The units in which effort is measured may be fishing trips, boat-hours, man-hours, etc. Man-hours is the smallest practical unit and is the most widely used. Whatever unit is chosen, from the standpoint of possible bias it is important to determine precisely what a unit represents. The usual problem is separation of fishing and non-fishing activity, and the appropriate estimators depend upon the objectives of the survey and the nature of the fishery.

In the Oneida Lake summer census, estimated effort represented total boat-hours spent on the lake by "stationary" boats (included boats traveling slowly, e.g., at trolling speed). Rapidly moving boats which could be distinguished by their wake were excluded from the counts. Thus the only non-fishing activity included in the estimated effort was the negligible "stationary" non-fishing time by anglers, and the equally small amount of "stationary" time by non-anglers. This choice of effort unit was dictated by our inability to distinguish fishing from non-fishing boats in our counting procedure, and by the need to make the units of effort comparable in both the estimates of total effort and catch per unit effort.

The latter objective arises because we used a ratio estmate of total catch (total effort times catch per unit effort). In a later section it will be shown how failure of these two units to be the same in the Oneida Lake survey, resulted in a biased total catch estimate.

CATCH RATE (FISHING SUCCESS)

Angler Contacts.

Accurate estimation of catch rate in a sport fishery will require personal contact with anglers in the field during or immediately after completion of their trip. In the Oneida Lake survey, anglers were contacted primarily on the lake while they were fishing. The basic information sought from each party was the amount of pre-interview fishing time and the number of each fish species in the catch. When conditions permitted, additional information was obtained on a sampling basis.

Experience in the Oneida Lake survey confirmed the following important aspects of conducting interviews:

(1) Natural ability and training of interviewers are both necessary to insure good quality information and to maintain good public relations. In particular, questions must be carefully phrased and interviewers must be alert to the problem of inaccurate responses.

(2) Interviews must be short. To get a wide variety of information it is advisable to construct classes of interviews, each class dealing with related items, and obtain only one class of information from each party interviewed.

(3) For an initial survey it will be worthwhile to conduct a small trial census to check out practical matters such as field forms or questionnaires, and field costs. A trial run will almost certainly uncover unforeseen problems.

Unit of Fishing Success.

Fishing success may be recorded for boats or parties or individual anglers and as catch per trip or catch per hour. Catch per hour is the more precise measure because catch and length of trip are correlated. Catch per man-hour is the unit most commonly used.

In the Oneida Lake census catch per boat-hour was used for estimation purposes in the summer fishery. Conversion to catch per man-hour was made by multiplying by average number of anglers per boat.

Roving Census.

In the Oneida survey interviewers systematically traversed the fishery contacting anglers in the midst of their fishing. This method has been referred to as a roving census, and it yields incomplete-trip catch data as opposed to completed-trip data. In comparison with sampling of completed trips the roving census often has the advantages of efficiency (from the standpoint of number of contacts per unit census time) and representative sampling of all classes of anglers. Usually, however, it is the completed trip catch rate that is desired, as for example when using the ratio estimate of total catch mentioned earlier. In this case a necessary condition for unbiasedness of incomplete-trip catch rates is that the probability of catching a fish in the first hour of a trip is the same as in the second hour, third hour, etc. Whether or not this condition is satisified depends upon the nature of the fishing process, i.e., on the behavior of both fish and anglers. This process is not measurable from a practical standpoint and herein lies a unique and major disadvantage of the roving census.

Bias arising from the nature of the fishing process can be estimated from catch-rate comparisons between completed and incompleted fishing trips. Such estimates of bias will be valid if completed trips are contacted with the same probability as incompleted trips, i.e., with the probability proportional to length of trip. This may be accomplished by contacting the same parties twice -- once in the midst of their trip with a properly designed roving census, and again at completion of their trip. Other methods based on roving census data alone can be used to detect bias, but either these methods have larger sampling errors or they do not give valid estimates of the size of bias.

In addition to bias from the nature of the fishing process, catch data from a roving census are also subject to bias from other more common aspects of sample surveys including sampling design, estimators used and response errors. The principal problems are briefly reviewed in the following sections.

Sample Design.

Improper sampling design can of course be a source of bias with either completed or incomplete-trip contacts. Usually sampling is done in several stages corresponding to whatever scheme is used to subdivide a fishing season into smaller units. We shall only consider within-day sampling of parties here since avoiding bias in other stages is a simple extension of the ideas involved in the within-day sample design.

We are concerned about possible systematic differences in catch rate with time of day and location in the fishery. Bias from such differences can be avoided by incorporating the following features into the within-day sampling design of a roving census:

(1) Divide the day into equal-length periods each of which represents the time required to make one complete circuit of the fishery.
(2) Randomly select one or more of these periods as well as the starting place and travel direction of each census trip.
(3) Systematically traverse the fishery contacting every k^{th} party (i.e., interview a constant proportion of parties in each section of the fishery).

The importance of these features depends upon the extent of systematic variation in fishing effort and catch rate with time of day and location. The basic difficulty in fulfilling the above sampling requirements is that when fishing effort fluctuates widely it is impossible to maintain a constant sampling rate and still complete a circuit of the fishery in a specified time. This problem can be reduced substantially in most cases simply by stratifying the day according to the distribution of fishing effort. For example, on the Oneida Lake fishery, nearly 40 percent of the daylight fishing activity on weekdays is concentrated in the period from 6 P.M. until dark. In this case simply stratifying daylight hours into two periods, pre- and post- 6 P.M., and putting roughly equal amounts of sampling effort into each period, will avoid bias of the type under consideration and may also result in a gain in precision. Note that so long as a measure of stratum size (total fishing effort in this case) is available unbiased estimates are obtainable whether or not the sampling fraction is the same in all strata.

The same ideas apply to classification of weeks into weekdays vs. weekend days (and holidays), and stratification of the season into periods of low effort and high effort. Certain characteristics of the distribution of effort are usually fairly stable in a given fishery such as weekday vs. weekend day fishing, and also the within-day pattern of effort on weekdays. However, seasonal patterns of fishing success and thus fishing effort, are unpredictable and can fluctuate widely. Therefore if you are concerned about monitoring such variations, or about the possibility of bias due to sampling anglers disproportionately to their abundance through time, it is important to recognize the following. For a fixed total sample size (seasonal total, say), as you subdivide the fishing season into smaller and smaller units (time strata), you improve your capability of monitoring sudden changes and you reduce the potential for bias from disproportionate sampling. Clearly the above arguments apply to any characteristic of a population of recreationers (e.g., recreational expenditures) which might exhibit systematic changes in composition through time and space.

Choice of Estimators.

As noted earlier, a ratio estimate of total catch will be biased unless the unit of effort used in catch rate estimates is the same as that used in estimating total effort. In the Oneida summer fishery, estimates of total effort represented essentially the boat-hours of actual fishing time by anglers. However, catch rate estimates included travel time between fishing sites, and the unit of effort was a boat-hour of fishing plus travel time. This difference in the units of effort resulted in a negative bias of 10 percent in total catch estimates. This bias is equivalent to the average ratio of travel time to "fishing time".

A ratio can be estimated either by a mean of individual ratios, $\bar{r}$, or a ratio of means, $\hat{R}$, and with respect to bias one estimator may be better than the other depending upon circumstances. The ratio of means (or totals) is a weighted mean, and in the context of a mean catch per hour, the weights are proportional to the trip lengths. On the other hand, the mean of ratios (individual catch rates) is an unweighted mean giving equal weight to each catch rate regardless of trip length. With respect to the roving census, some factors which are involved in the choice between these two estimators are:

(1) the parameter sought.
(2) relation between catch rate and length of completed trip.
(3) errors in angler estimates of pre-interview fishing time.
(4) whether or not early and late parts of trips are equally successful (i.e., nature of the fishing process).

Without going into a number of details here, I have concluded that $\hat{R}$ probably will be the better estimator for the roving census in most cases. The manner in which some of the above factors could generate bias is indicated briefly in the following sections.

Response Errors.

On a theoretical basis, catch rate estimates derived from a roving census would appear to be sensitive to errors in angler estimates of pre-interview fishing time. Even a slight tendency for anglers to consistently underestimate or overestimate their fishing time, particularly in the first hour of their trip, might generate a significant bias in the mean catch rate.[/1] In the first half-hour of fishing, say, an error of 15 minutes in reported pre-interview time can result in a large difference between the true and the recorded estimate of catch rate for a single trip. The reason for being concerned with this first hour is because in the roving census the largest proportion of contacts occur within the first hour

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[/1] In fact it can be shown algebraically that even if responses are unbiased, it is possible for unintentional errors alone to generate a biased catch rate; however, this would require special circumstances which appear not to have occurred in the Oneida survey.

of fishing, the next largest proportion within the second hour, etc. For example on Oneida Lake, approximately one-third of all contacts occurred in the first hour, and one-quarter in the second hour. Thus even a slight tendency for angler responses to be biased, would be magnified by the fact that first-hour catch rates are represented most frequently in the combined sample of incomplete trips.

There is slight evidence in the Oneida survey that anglers may tend to underestimate pre-interview time early in the trip (when they perhaps are most attentive), and this may have been partly responsible for the fact that average walleye catch rates were higher in the first hour than in later hours of trips. This same pattern has been reported from other fisheries. The potential for such bias arising from response errors seems large enough to warrant checking in other roving surveys.

Nature of Fishing Process as Source of Bias.

By far the most troublesome potential source of bias in a roving census is the nature of the fishing process. Di Costanzo (1956) first studied this problem in detail and noted that regardless of the sample design or estimators used, incomplete-trip catch rates are subject to bias unless on the average, catch rate is constant throughout all portions of a trip. Examples of ways in which this requirement could be violated are:

(1) anglers are more attentive at beginning of trips or visit the best spots first.

(2) fishing success is characteristically highest in certain parts of fishing trips (e.g., if fishing is best early in the morning, or as in the Oneida Lake ice fishery, anglers pick up an accumulation of fish on their "set lines" within the first few minutes after arrival at their fishing site).

Summer walleye catch rates in Oneida Lake had a small positive bias (< 5%) because the catch rate was higher in the first hour of fishing than in later hours. Part of this difference was due to the fact that the proportion of fishing to non-fishing time was higher in the first hour than in later hours as would be generally expected. That is, catch rate actually was slightly higher in the first hour of trips because effort was virtually uninterrupted in the first hour.

In the winter fishery anglers with set lines have a substantially higher catch rate in their first hour than in later hours. A hypothetical roving census based on a representative sample of winter anglers showed that catch rates would have a positive bias of 15 to 30% depending upon whether $\hat{R}$ or $\bar{r}$ were used.

TOTAL CATCH

The primary problems of bias in the ratio estimate of total catch used in the Oneida Lake study have already been referred to earlier. Clearly any bias in estimate of catch rate or total effort will be incorporated into the total catch estimate. It should be noted that there are other types of ratio estimates of total catch. Robson (1960) described a technique which would provide unbiased ratio estimates of catch but to my knowledge it has not yet been applied in practice.

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